The invention concerns retroreflecting metrology devices used in particular to measure deformation of natural structures (the ground, rock formations) or man-made structures (civil engineering works, embankments, cuttings).

Metrology measurements on such structures are conventionally effected by means of rangefinders which use "Invar" (registered trademark) wires. In outline, they entail implanting in the structure whose dimensional evolution is to be checked supports on which wire attachment members are removably mounted, using an adjustment member to stretch wires whose ends have been attached to two respective attachment members, measuring (allowing for the length of the wires) the distances between reference points of the attachment members, removing the equipment with the exception of the supports, and repeating the above operations each time the dimensional evolution of the structure is to be checked.

The supports are therefore permanently anchored in the structure but the rest of the equipment is removable. The attachment members have a structure such that merely knowing the distance between the respective attachment points of two members, between which one or more wires are stretched, enables the distance between the reference points thereof to be deduced so that, in the absence of deformation, the measurements are reproducible, even at intervals of several years, and so that the changes in the measured distances are a perfect reflection of the deformations of the structure. To enable measurements to be be effected over a wide range of distances, wires of calibrated length can be joined together end-to-end; to obtain great accuracy an attachment member, one or more wires and an adjustment member comprising a section of measurable adjustable length and a calibrated tensioner

are inserted between two reference points; thus the wires are always tensioned with the same tension; as they are made of Invar, their length varies little with temperature. The distance between the two reference points in a straight line from one reference point to the other is therefore equal to the sum of the lengths of the wires tensioned to the appropriate tension plus the length of the adjustment member plus the length of the attachment member between the calibrated wire and the corresponding reference point. The reproducibility of the measurements is naturally related to the necessity for the reference point to be always identically positioned relative to the supports of all the attachment members.

Figure 1 illustrates the use of such rangefinders to measure changes in the cross section of the vault of a tunnel, for example a railway tunnel in an underground station.

Seven supports, each of which can removably carry an attachment member, are anchored in the plane of the cross section; a support A is anchored into the keystone, two supports B and C are symmetrically anchored at the corners of the platforms overlying the tracks, two supports D and E are symmetrically anchored to the skewbacks of the vault at the same level and two supports F and G are symmetrically anchored in the vault or at the springers, at the same level, respectively between the supports D and E and the keystone support A.

The wires are respectively tensioned between B and D, D and F, F and A, A and G, G and E, E and C, C and B and there are therefore only seven distances to be measured; with seven supports it is theoretically possible to check 21 distances, but in most cases it is sufficient to check 17 distances to obtain a good image of the evolution of the structure.

Figure 2 shows diagrammatically a device including a support 1 and an attachment member 2 which are known in the art and an assembly member 3 by means of which the attachment member is fixed to the support.

The support 1 includes, along a central axis, a support base 11 adapted to be fixed into the structure whose evolution is to be checked and a receptacle head 12 connected by a transition region 13. The head 12 is adapted to carry the assembly member, externally of the structure. The support base can have projections at its perimeter to anchor it more reliably into the structure, for example a longitudinal succession of annular projections or a screwthread of appropriate profile if it is cylindrical (not shown); it can be anchored by embedding it in resin or in expanding cement, for example. The head 12 is generally cylindrical and has an external screwthread 14 to enable the assembly member 3, which has an inside screwthread 31 for this purpose, to be screwed onto it. The transition region 13 is frustoconical. The head 12 includes a generally cylindrical housing 15 open to the outside at the free end opposite the support base 11 via a frustoconical seat 16 consisting of a bevel at an angle in the range from approximately 40° to approximately 50°. For technological reasons, the outside screwthread 14 preferably does not extend as far as the free end of the support and in the region of the free end of the support the outside diameter of the support is not greater than the diameter at the root of the screwthread.

The attachment member 2 is made up of several components and to be more precise includes a bush 21 having a generally cylindrical body adapted to be inserted into the housing 15 and a flange which bears on the frustoconical seat 16. The bush 21 includes a central passage in which is accommodated a fixing rod 22

for an attachment finger 23 fixed to the rod externally of the head 12 to pivot about a pivot 24 perpendicular to the longitudinal central axis of the support 1. The fixing rod 22 has a screwthread along its end region accommodated in the head 12 onto which is screwed a nut for fixing the rod to the bush, bearing against a face of the bush with a washer between them. The pivot 24 is accommodated in a transverse bore in the opposite end region of the fixing rod 22; this region of the fixing rod has an area which bears against the face of the flange of the bush 21 outside the head 12 so that the longitudinal axis of the pivot 24 is at a fixed distance from the outside face of the flange. The point of intersection of the axis of the pivot 24 and of the longitudinal central axis of the support 1 to which it is perpendicular therefore constitutes the reference point of the attachment member 2. The axis of the pivot 24 can therefore be oriented in any direction in the plane parallel to the face of the flange external to the head 12 at a distance equal to that between the reference point and that face, and the attachment finger 23 can be pivoted in a vertical plane through an angle of at least 180° if its outside shape is chosen accordingly. The attachment finger 23 has a hook for attaching Invar wires near its end opposite its articulation to the pivot 24.

The assembly member 3 takes the form of a ring forming a nut whose inside screwthread 31 cooperates with the outside screwthread 14 of the support 1; it has an inside surface 32 for clamping the flange against the head 12, with the lateral surface of the flange pressed against the frustoconical seat 16; the outside surface of the ring can be knurled to facilitate tightening it.

When the respective attachment members of two devices as described above are connected to each other by Invar wires and an adjustment member, and the wires and

the adjustment member have been aligned with the attachment finger 23, the distance whose evolution is to be checked is that between the longitudinal axes of the respective two pivots 24 of the two devices.

Repetitive measurements using the above equipment are time-consuming and costly and it is desirable to use simpler and faster means of studying the evolution of the same structures.

However, measurements effected until now by other techniques, in particular optical techniques, supply results that are comparable with those obtained using the equipment just described only after lengthy and difficult (or even impossible) corrections.

The object of the invention is to remedy these drawbacks and to provide optical measuring equipment which gives the same measurement results as the prior art equipment in the absence of evolution in the structures checked, in order to avoid any problem of continuity in studying the evolution of structures previously checked by means of the prior art equipment.

To this end, the invention therefore concerns a retroreflecting metrology target marker device comprising a target member and a support for that target member, characterized in that the support includes a receptacle head for inserting a target member, that receptacle head including a housing for inserting the target member opening to the outside via an outwardly flared frustoconical seat, and the target member includes a flange having a spherical annular lateral surface adapted to bear tangentially against the frustoconical seat, and a plate extending out of the support and upstanding perpendicularly on the flange in an equatorial plane of a spherical surface of which the lateral surface of the spherical ring flange is part, that plate having two parallel plane faces at least one of which is

retroreflecting or covered with a retroreflecting coating and including a hole passing completely through it and centred on an axis perpendicular to the faces of the plate and passing through the centre of said spherical surface.

By virtue of the above structure, it is possible to provide a target member adapted to be inserted not only in a support provided especially for it but also in a prior art support originally adapted to receive an Invar wire attachment member, to perform measurements using a theodolite, to obtain identical measurement results for the same structure, if it has not undergone any deformation, and thereby to continue checking the dimensional evolution of the structure without aberrant results or interruptions due to changing the measuring method.

The device according to the invention can also have one or more of the following features:

- the hole passing through the plate has at least one frustoconical region through which it opens to the outside, in a flared fashion, to optimize inclined sighting;

- the hole passing through the plate has two frustoconical regions through which it opens to the outside on respective opposite sides of the plate, in flared fashion, to optimize inclined sighting;

- both faces of the plate are retroreflecting or covered with a retroreflecting coating;

- the hole passing through the plate has at least one frustoconical region through which it opens to the outside, in flared fashion, and the inclination of the wall of the frustoconical region to the axis on which the hole is centred is from approximately 35° to approximately 45°;

- the plate is upstanding on a circular increased

thickness portion of one face of the flange;

- the target member includes a generally cylindrical body joined to the flange and adapted to be inserted into the housing of the receptacle head of the support;

- the support includes a support base adapted to be anchored into a structure on which metrology measurements are to be effected;

- it includes an assembly member in the form of a ring forming a nut having an inside screwthread cooperating with an outside screwthread of the receptacle head of the support and an inside surface for clamping the flange against the head; and

- the spherical surface is part of a sphere having a diameter from approximately 25 mm to approximately 35 mm.

Other features and advantages of the invention will emerge from the following description of one embodiment of the invention, which description is given by way of non-limiting example and is illustrated by the accompanying drawings, in which:

- figure 1 is a diagram showing prior art metrology devices for dimensional measurements on a tunnel,

- figure 2 is a diagrammatic external view of one embodiment of a prior art metrology device,

- figure 3 is a diagrammatic front view of a target member included in a target marker device according to the invention, and

- figure 4 is a diagrammatic partial view in longitudinal section of a target marker device according to the invention including the target member from figure 3, which is shown in profile.

Means in figures 3 and 4 identical to means in figure 2 are designated by the same reference numbers.

The target marker device according to the invention

shown in figure 4 includes, like the prior art device shown in figure 2, a support 1, a member adapted to be inserted into the support 1 and an assembly member 3 by means of which that member is fixed to the support; however, the member adapted to be inserted into the support 1 is not an Invar wire attachment member but a target member 4 described below and shown in figure 3.

Like that from figure 2, the support 1 of the device according to the invention includes, along a central axis, a support base 11 adapted to be fixed into the structure whose evolution is to be checked and a receptacle head 12 joined by a transition region 13. The head 12 is adapted to carry the assembly member, externally of the structure. The support base can have projections at its perimeter to make the anchorage in the structure more reliable, for example a longitudinal succession of annular projections or a screwthread of appropriate profile, anchorage being effected by embedding the device in resin or expanding cement, for example.

The head 12 is cylindrical and has an outside screwthread 14 for screwing on the assembly member 3, which to this end has an inside screwthread 31. The transition region 13 is frustoconical. The head 12 includes a generally cylindrical housing 15 opening to the outside at the free end of the support opposite the support base 11 via a frustoconical seat 16 consisting of a bevel whose angle is in a range from approximately 40° to approximately 50°, i.e. whose cone angle is from approximately 80° to approximately 100°. The outside screwthread 14 preferably does not reach this free end of the support and in the region of this end the outside diameter of the support is not greater than the diameter at the root of the screwthread.

The target member 4 includes a generally

cylindrical body 41 adapted to be inserted into the housing 15 with a smooth sliding fit or a slight clearance in the housing, and a bearing flange 42 on the frustoconical seat 16 preferably joined to the body by a groove 43; the flange 42 has a spherical annular lateral surface adapted to bear tangentially against the outwardly flared seat, the spherical ring being part of a spherical surface 44 of an imaginary sphere centred on the central axis of the support 1, which is also that of the cylindrical housing 15 and the seat 16; on the face of the flange 42 opposite that from which the body 41 is extended by the groove 43 is a plate 45 upstanding perpendicularly in an equatorial plane of the spherical surface 44 and adapted to extend out of the support when the target member is inserted in it.

The plate 45 has two parallel plane faces at least one of which is retroreflecting or has a retroreflective coating to constitute a sighting surface; both faces are preferably retroreflecting or have a retroreflecting coating for visible light rays or rays at wavelengths close to the visible spectrum in order to constitute two sighting surfaces; the plate includes a hole 46 for optimizing sighting which passes completely through it and is centred on an axis which is perpendicular to the faces of the plate and to the longitudinal axis of the housing 15 and the seat 16 and also passes through the centre of the spherical surface 44. The hole 46 preferably has a circular cross section throughout its length; it can have a cylindrical central portion and has at least one frustoconical region or countersink 461 through which it opens to the outside in a flared fashion; it preferably has two frustoconical regions 461 opening to the outside in a flared fashion on respective opposite sides of the plate 45; because the plate is generally thin, the hole generally has no cylindrical

central portion of significant length and the two frustoconical regions or countersinks 461 are joined at their smaller base.

If one or each face has a retroreflecting coating, the coating naturally itself has a hole through it whose shape and dimensions are the same as those of the holes in the plate in the same area; the retroreflecting coating is advantageously a retroreflecting adhesive film.

The inclination of the facing 461 relative to the axis of the hole is preferably from approximately 35° to 45° to facilitate sighting by means of a theodolite.

The plate 45 is upstanding on a circular increased thickness portion 47 of the face of the flange 42 opposite that from which the body 41 extends and the function of which is explained below. The thickness of the plate is a few millimetres, for example from approximately 1 mm to approximately 5 mm.

For a seat 16 which extends between a small diameter of approximately 20 mm and a large diameter of approximately 30 mm, the diameter of the sphere 44 is from approximately 25 mm to approximately 35 mm.

A passage 48, which is cylindrical, for example, passes completely through the body 41, the groove 43, the flange 42 and its increased thickness portion to facilitate the insertion of the body 41 into the housing 15 by enabling the air contained therein to escape as the body 41 advances into the housing.

The assembly member 3 is of a ring forming a nut whose inside screwthread 31 cooperates with the outside screwthread 14 on the support 1 and has an inside surface 32 for clamping the flange against the head 12. The spherical surface of the flange is pressed against the frustoconical surface of the seat 16 tangentially to the frustoconical surface. The ring can be knurled or

provided with flats to facilitate tightening it.

The dimensions of the circular increased thickness portion 47 of the flange 42 are adapted to enable the increased thickness portion to be inserted into the central hole of the ring 3 surrounded by the inside clamping surface 32 with the outside face of the ring almost perfectly flush with the face of the increased thickness portion that carries the plate 45, which enables all of the retroreflecting surface of the plate to be used for measurements perpendicular to that surface.

When the respective target members of the two devices described above are in place, the distance whose evolution is to be checked is that between the respective holes of the target members, as measured by an optical technique, for example using a tacheometer or electronic theodolite with infrared rangefinder; this kind of measurement is fast even when a large number of distances is to be measured, and lends itself to automatic logging of the results.

The structure that has just been described also makes the target members according to the invention interchangeable with the prior art attachment members and in particular members forming part of devices known as orientable rangefinders, using the same supports anchored in the structure to be measured and producing the same results.